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The Trade Sector in INTERMOD

by

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ABSTRACT

This paper describes the trade sector in INTERMOD, a linked international model constructed at the Department of Finance using annual data. Our model follows closely the structure of a policy simulation model developed at the IMF (MULTIMOD), the most important difference being that INTERMOD has separate blocks for each of the G-7 countries whereas MULTIMOD aggregates the four smaller countries (France, the U.K., Italy, and Canada) into a single region. Both models contain blocks for the aggregate of the eleven smaller industrial countries and for the developing countries.

The equations describing trade flows are based on the approach of Samuelson and Kurihara [1980]. Aggregation assumptions permit the complete set of bilateral trade flows for each country to be consolidated into a single 'manufactured' export and import (trade in crude petroleum and commodity imports from the developing countries are treated separately). The directly-estimated parameters using annual data yield an average long-run price elasticity of export demand of 0.71, while the average import price elasticity is 0.70. Simulation exercises on the trade block indicate that exchange rate changes have little effect on trade balances in the first year. The 'J-curve' effect decays in the long-run such that a 10 per cent exchange rate appreciation causes a deterioration in the trade balance ranging from 0.4 per cent of GDP for Italy to 1.4 per cent of GDP for Germany.

RÉSUMÉ

Ce document décrit le secteur commercial du modèle INTERMOD, un modèle international mondial construit par le ministère des Finances à partir de données annuelles. Notre modèle copie sensiblement la structure d'un modèle de simulation de politiques macroéconomiques élaboré par le Fond Monétaire International (MULTIMOD), la différence majeure étant que INTERMOD comporte des blocs distincts pour chacun des pays du Groupe des 7 alors que MULTIMOD réunit dans une même région les quatre plus petits pays du Groupe, soit la France, le Royaume-Uni, l'Italie et le Canada. Les deux modèles renferment aussi des blocs pour le regroupement des onze pays industrialisés plus petits et des pays en voie de développement.

Les équations qui décrivent les transactions commerciales sont fondées sur la méthode de Samuelson et Kurihara [1980]. Des hypothèses concernant les agrégats permettent de regrouper l'ensemble des transactions commerciales bilatérales de chaque pays en un seul bloc de "produits manufacturés exportés et importés". (Le commerce de pétrole brut et de biens importés des pays en voie de développement est traité séparément.) Les paramètres estimés directement à partir des données annuelles donnent un taux d'élasticité moyen du prix à long terme des exportations de 0,71, alors que le taux d'élasticité moyen du prix des importations est de 0,70. Les essais simulés du bloc commercial indiquent que les variations du taux de change ont peu d'effet sur les balances commerciales au cours de la première année. L'effet de "courbe J" se détériore à long terme, de sorte qu'une appréciation de 10 p. 100 du taux de change entraîne une détérioration de la balance commerciale allant de 0,4 p. 100 du PIB pour l'Italie à 1,4 p. 100 du PIB pour l'Allemagne.

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1. Introduction

The Department of Finance has been engaged over the past year in the construction of a linked multi-country model using annual data, INTERMOD, for the purpose of performing policy simulation exercises in an international context. We have closely followed similar work undertaken at the IMF as reflected in their simulation model MULTIMOD.¹ The principal difference between INTERMOD and the IMF model is the level of geographic disaggregation: INTERMOD contains separate country blocks for all the G-7 countries, while MULTIMOD aggregates the four smaller G-7 countries into a single region. Both models contain separate blocks for the smaller industrial countries and the developing countries.

This paper describes the specification and estimation of the trade sector for manufactured goods in INTERMOD²; the differences between our approach and that used in MULTIMOD are discussed where relevant. The next section explains the derivation of the structural equations using the Samuelson-Kurihara approach to modelling multilateral trade flows. The third section presents the estimation results for the model parameters. Finally, the implied elasticities of imports and exports with respect to changes in the exogenous variables are generated through simulations of the trade block.

2. The Samuelson-Kurihara Framework

The Samuelson-Kurihara approach to modelling trade flows consists of aggregation assumptions that permit each country's exports and imports to be treated as composite commodities.³ In both INTERMOD and MULTIMOD, these composite traded goods represent transactions in all goods and non-factor services with two exceptions: trade in crude petroleum, and imports by industrial countries of the commodity exports of developing countries. This paper discusses the equations for the aggregate traded goods of the industrial countries excluding these two components -- the equations that determine oil trade and commodity imports are presented in Helliwell et al [1988].

We start by outlining the nature of the aggregation restrictions, followed by an analysis of how the multilateral trade weights necessary for estimation and simulation are derived. The specification of each equation is

¹ The IMF model is documented in Masson et al [1988]. An overview of INTERMOD is presented in Helliwell, et al [1988].

² Although MULTIMOD uses the terminology 'manufactured goods', the trade aggregates for the industrial countries include trade in all goods and (non-factor) services excluding crude petroleum and imports of commodities from developing countries.

³ This approach is described in more detail in Samuelson and Kurihara [1980].

then described in more detail; the section ends with a discussion of how the world trade discrepancy is allocated across countries in simulation exercises.

2.1 Aggregation Assumptions

The equations which determine the price and volume of trade flows for representative country i are shown in (2.1.1) to (2.1.4). Dynamic elements have been suppressed, as have adjustments necessary to account for discrepancies between the value of world imports and exports. Greek letters represent estimated parameters, while $\ln(x)$ denotes the natural logarithm of x :

$$\text{export volume: } \ln(XM_i) = \beta_0 + \beta_1 \ln(FM_i) + \beta_2 REER_i \quad (2.1.1)$$

$$\text{export price: } \ln(PXM_i) = \beta_0 + \beta_1 \ln(PFM_i) + (1-\beta_1) \ln(PGNPNO_i) \quad (2.1.2)$$

$$\text{import volume: } \ln(IM_i) = \beta_0 + \beta_1 \ln(A_i) + \beta_2 \ln(PIM_i/PGNPNO_i) \quad (2.1.3)$$

$$\text{import price: } PIM_i = \sum_j (s_{ij} * PXM_j * ER_j) \quad (2.1.4)$$

$PGNPNO_i$ is country i 's GDP deflator excluding oil production, A_i is domestic absorption, ER_i the bilateral U.S. dollar exchange rate normalized to equal one in 1980 (and always equal to one for the U.S.), while the following variables are defined in more detail in the next section:

- FM_i = activity in foreign markets
- $REER_i$ = real competitiveness index
- PFM_i = price in foreign markets
- s_{ij} = share of country j in country i 's total imports .

Rather than modelling each of the bilateral trade relationships separately, equations are specified for the total value of each country's imports and exports based on aggregate measures of the size of foreign markets, competitiveness, and import prices. The aggregation assumptions used in the Samuelson-Kurihara approach are embodied in the synthetic variables FM , $REER$, PFM , and PIM in the above equations. In particular, it is assumed that:

- The elasticity of demand for a country's exports with respect to changes in the import volumes of trading partners is the same for all partners, permitting the use of a single 'foreign markets' variable in the export volume equation.
- Income and price elasticities of demand for imports from different partners are the same, thus a country's imports can be treated as a single composite commodity.

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- Cross-price elasticities of demand for exports are identical, implying a unique competitiveness index for each country's exports.
- Exporters do not price discriminate in foreign markets, so that there is a unique export price for each country's composite manufactured good.

These aggregation restrictions mean that the full set of multilateral trade flows does not have to be modelled explicitly, reducing both data requirements and estimation complexity.⁴

2.2 Deriving the Multilateral Weights

In order to operationalize the aggregation restrictions described above, weights are constructed that reflect the importance of each foreign country in the home country's trade relationships. These are then used to derive the synthetic variables FM, REER, PIM, and PFM. We start with a matrix of each country's total exports and imports disaggregated according to destination and source for a representative base period. Following the MULTIMOD lead, the reference period is 1980. (As all price indices in the model are also based in 1980, nominal and real trade flows are identical in the reference year.) We represent the trade matrix as follows:

$$X = [x_{ij}] , \quad (2.2.1)$$

where x_{ij} is the value in U.S. dollars of exports from country i to country j (which is identically equal to the value of country j 's imports from country i). The matrix is of dimension 9×9 given our disaggregation into the individual members of the G-7, the smaller industrial countries as a group, and the rest of the world (the diagonal elements are equal to zero by definition).

The row sums of X represent the total exports of each country. Thus dividing each element of X by its row sum gives a matrix of export shares, which we call L . The ij^{th} element of this matrix is the share of country i 's total exports destined for country j -- the row sums equal one. Similarly, dividing each element of X by the corresponding column sum gives the matrix of import shares, denoted by S . The element s_{ij} is the share of country j 's total imports which originates in country i . The actual values for the three

⁴ Aggregating in this way reduces the number of equations in the model necessary to explain the volume of trade flows from $n*(n-1)$ to $2*n$. In INTERMOD, which has nine trading areas, the number of estimated equations is lowered to 18 from 72.

Table 2.1

Matrix of 1980 Export Values (X_{ij})
(million of U.S. dollars)

Exports by:	Exports to:								
	<u>US</u>	<u>JA</u>	<u>GR</u>	<u>FR</u>	<u>UK</u>	<u>IT</u>	<u>CA</u>	<u>SI</u>	<u>RW</u>
US	0	20790	10960	7490	12700	5510	35400	32520	95430
JA	31910	0	5790	2030	3800	960	2450	12180	71310
GE	11820	2190	0	25660	12640	16490	1200	73420	49440
FR	4930	1090	17850	0	7770	13910	680	29230	40560
UK	10590	1390	17925	8340	0	4410	1760	38370	33420
IT	4120	710	14260	11770	4740	0	490	15270	26330
CA	41070	3750	1390	860	2710	850	0	4110	12990
SI	15080	9310	62440	31990	35600	17210	2140	0	73120
RW	29080	6600	10080	3500	5590	3530	1820	12460	0

Table 2.2

Matrix of 1980 Export Shares (L_{ij})

Exports by:	Share exported to:								
	<u>US</u>	<u>JA</u>	<u>GR</u>	<u>FR</u>	<u>UK</u>	<u>IT</u>	<u>CA</u>	<u>SI</u>	<u>RW</u>
US	0	0.094	0.050	0.034	0.058	0.025	0.160	0.147	0.432
JA	0.245	0	0.044	0.016	0.029	0.007	0.019	0.093	0.547
GE	0.061	0.011	0	0.133	0.066	0.086	0.006	0.381	0.256
FR	0.042	0.009	0.154	0	0.067	0.120	0.006	0.252	0.350
UK	0.091	0.012	0.154	0.072	0	0.038	0.015	0.330	0.288
IT	0.053	0.009	0.184	0.151	0.061	0	0.006	0.197	0.339
CA	0.606	0.055	0.021	0.013	0.040	0.013	0	0.061	0.192
SI	0.061	0.038	0.253	0.130	0.144	0.070	0.009	0	0.296
RW	0.400	0.091	0.139	0.048	0.077	0.049	0.025	0.171	0

Note: Row sums equal 1.0 .

Table 2.3

Matrix of 1980 Import Shares (S_{ij})

Share of:	In total imports of:								
	<u>US</u>	<u>JA</u>	<u>GR</u>	<u>FR</u>	<u>UK</u>	<u>IT</u>	<u>CA</u>	<u>SI</u>	<u>RW</u>
US	0	0.454	0.078	0.082	0.148	0.088	0.771	0.149	0.237
JA	0.215	0	0.041	0.022	0.044	0.015	0.053	0.056	0.177
GE	0.080	0.048	0	0.280	0.148	0.262	0.026	0.337	0.123
FR	0.033	0.024	0.127	0	0.091	0.221	0.015	0.134	0.101
UK	0.071	0.030	0.127	0.091	0	0.070	0.038	0.176	0.083
IT	0.028	0.015	0.101	0.128	0.055	0	0.011	0.070	0.065
CA	0.276	0.082	0.010	0.009	0.032	0.014	0	0.019	0.032
SI	0.101	0.203	0.444	0.349	0.416	0.274	0.047	0	0.182
RW	0.196	0.144	0.072	0.038	0.065	0.056	0.040	0.057	0

Note: Column sums equal 1.0 .

Table 2.4

Matrix of Competitiveness Weights (W_{ij})

Index for:	Weight of:								
	<u>US</u>	<u>JA</u>	<u>GR</u>	<u>FR</u>	<u>UK</u>	<u>IT</u>	<u>CA</u>	<u>SI</u>	<u>RW</u>
US	-1.000	0.154	0.182	0.114	0.122	0.073	0.039	0.243	0.074
JA	0.198	-1.000	0.151	0.101	0.103	0.068	0.111	0.194	0.074
GE	0.202	0.108	-1.000	0.142	0.156	0.090	0.045	0.191	0.066
FR	0.183	0.108	0.201	-1.000	0.120	0.069	0.037	0.228	0.053
UK	0.176	0.110	0.216	0.121	-1.000	0.080	0.049	0.187	0.063
IT	0.166	0.103	0.179	0.099	0.114	-1.000	0.037	0.252	0.050
CA	0.093	0.222	0.128	0.067	0.094	0.048	-1.000	0.168	0.182
SI	0.211	0.115	0.170	0.141	0.119	0.112	0.050	-1.000	0.082
RW	0.128	0.130	0.146	0.082	0.099	0.055	0.155	0.205	-1.000

Note: $W_{ij} = (L_{ij} / (1 - S_{ij})) * S_{ij}$.
 Diagonal elements set equal to minus one .
 Row sums equal zero .

matrices are shown in Tables 2.1, 2.2, and 2.3 respectively.⁵ The role played by these matrices in the construction of the synthetic variables is described in the next section.

2.3 The Specification of the Equations

The trade block in each of the country models can be ordered recursively. The model first solves for export prices as a function of domestic and foreign GDP deflators. These then determine import prices, which enter into the import volume equations. Export volumes are based on the imports of trading partners and relative export deflators.

Starting with export prices, equation (2.1.2) is a semi-reduced form in the domestic GDP deflator (excluding oil production) and a weighted sum of the non-oil GDP deflators of trading partners converted into domestic currency.⁶ The parameter β_1 reflects the relative slopes of the demand and supply curves for exports.⁷ The weights on foreign prices used to construct the PFM variable should reflect the elasticity of demand of home-country exports with respect to a change in each of the foreign prices. MULTIMOD uses 'real competitiveness weights' (denoted by w_{ij}) for this purpose that measure the change in the home country's share in foreign import markets when relative prices change. However, as discussed in Appendix A, these will not generally be full price elasticities, as the total volume of foreign imports is also a function of relative prices. This problem is particularly important in the case of the Canada-U.S. bilateral trade relationship: the overall importance of U.S. prices to Canadian exports is much higher than the third-country competitiveness weight of 0.093. The INTERMOD approach involves adjusting the competitiveness weights to account for the direct effects on import volumes of changes in prices -- the details are discussed in Appendix A. The expression we use for foreign prices is then:

$$\ln(\text{PFM}_i) = \left(\sum_j ((w_{ij} + l_{ij})/2) * \ln(\text{PGNPNO}_j * \text{ER}_j) \right) - \ln(\text{ER}_i)$$

⁵ The country mnemonics used are: US (United States), JA (Japan), GR (Germany), FR (France), UK (United Kingdom), IT (Italy), CA (Canada), SI (Small Industrial), RW (Rest of World). Because of data availability problems, the X matrix used to construct the weights is based on trade in goods only: in future work we hope to incorporate non-factor services.

⁶ The MULTIMOD specification is slightly different in that foreign export prices are used to construct PFM as opposed to GNP deflators. We prefer the latter approach, in that the interpretation of the export price equation as a semi-reduced-form is more direct.

⁷ For instance, a coefficient of unity on domestic prices would be consistent with either a perfectly elastic supply curve or a perfectly inelastic demand curve for exports. In INTERMOD, only the first interpretation is legitimate given that the estimated elasticities of demand are finite.

Import prices are modelled as a weighted average of the export prices of each country's trading partners converted into domestic currency, using base-period import shares:

$$PIM_i = (\sum_j s_{ji} * PXM_j * ER_j) / ER_i .$$

This index will be an exact measure of actual import prices if import volume shares remain constant over time (i.e. there is no substitution among imports).⁸

The volume of imports is modelled as a demand relationship that depends on total domestic absorption and the logarithm of the aggregate import price relative to the domestic GDP deflator. The elasticity of substitution between imports and domestic output in consumption is then a function of the parameter β_2 .

Export volumes depend on the level of trading partners' imports and a competitiveness index. The form of equation (2.1.1) and the way in which the synthetic variables FM and REER are constructed can be explained in terms of the identity which relates exports of country i to imports of its trading partners in the 1980 base period, where the s_{ij} refer to the corresponding elements of the S matrix:

$$XM_i = \sum_j (s_{ij} * IM_j) . \quad (2.3.2)$$

We take a first-order expansion of (2.3.2) such that both sides represent deviations from 1980 values -- the difference between the observed and the 1980 value of x is represented by dx. Then the total change in exports from the base period can be expressed as the sum of two terms involving changes in the IM_j and the s_{ij} respectively:

$$dXM_i = \sum_j (s_{ij} * dIM_j) + \sum_j (IM_j * ds_{ij}) . \quad (2.3.3)$$

The first term in the above expression gives the change in exports associated with a change in foreign imports, holding market shares constant. This is summarized in the definition of the foreign markets variable:

⁸ In contrast, unit elasticities of substitution between import categories would imply summing the logarithms of export prices in the above expression.

$$dFM_1 = \sum_j (s_{1j} * dIM_j) .$$

Dividing through by XM_1 such that the left-hand side of (2.3.3) is approximately the change in the logarithm of exports from its base-period value, and making use of the definition of FM, we have:

$$d\ln(XM_1) = d\ln(FM_1) + \sum_j (IM_j/XM_1) * ds_{1j} . \quad (2.3.4)$$

The second term on the right-hand side of (2.3.4) gives the change in exports associated with a change in foreign market shares, holding the total volume of foreign imports constant -- these share changes are sometimes referred to as 'third-country' effects. The specification of the ds_{1j} terms is a central feature of the Samuelson-Kurihara approach. In Appendix B, we derive the model which underlies changes in import shares. In general, the s_{1j} depend on both foreign export prices and the level of country j 's total imports (if import demands are not homothetic). The foreign export prices are aggregated using a double-weighting scheme which takes into account the share of home-country exports going to each foreign market as well as the sources of foreign imports -- the result is summarized in the competitiveness variable REER. We substitute this expression into (2.3.4), and make a further approximation by expressing the equation in terms of deviations from sample means as opposed to 1980 values:

$$\begin{aligned} \ln(XM_1) &= \alpha + (1+\tau) * \ln(FM_1) + \beta * \sum_j (w_{1j} * \ln(PXM_j * ER_j)) \\ &= \alpha + (1+\tau) * \ln(FM_1) + \beta * REER_1 , \end{aligned}$$

where: $w_{11} = -1$

$$w_{1j} = \sum_k ((s_{jk} * l_{1k}) / (1 - s_{1k})) .$$

The row sums of the matrix defined by the w_{1j} s equal zero, ensuring that the competitiveness indices REER depend on relative as opposed to absolute price levels.

The competitiveness weights used in the model are shown in Table 2.4. It should be noted that these are not what would normally be used to construct an effective exchange rate. This is because they only reflect the impact on exports of changes in import shares, holding the aggregate level of each country's imports constant. Thus the weight on U.S. prices in the Canadian index is small, as the two countries compete relatively little in third

markets. Nevertheless, the total effect on Canadian exports of a change in U.S. prices is large, as U.S. prices directly affect the level of U.S. imports and thus the Canadian 'foreign markets' variable. Similarly, the weight on Canada in the U.S. real competitiveness index is only 0.039, whereas the total influence of Canadian prices in determining U.S. exports is much larger (In the last section we perform simulations of the trade sector to identify the full price elasticities of exports with respect to changes in relative prices.)

2.4 Adding-Up Constraints

The specification of the individual equations provides no guarantee that the fitted values of world imports and exports will be equal in periods other than the base year. In general, there will be discrepancies in both the nominal and real values of world trade due to approximation errors in the various relationships, and because the import and export equations are not based on exactly the same model of the behaviour of the import shares.

This problem is resolved by an allocation of the trade residuals across export volume and import price equations. Specifically, parameters are calculated which reflect the base-period weight of each country in world trade, defined as the sum of each country's imports and exports divided by total world trade. Then the 'adjusted' values of export volumes and import prices are constructed as follows:

$$XMA_i = XM_i + t_i * WTRADER$$

$$PIMA_i = PIM_i + t_i * (WTRADE / IM_i) ,$$

where: $WTRADER$ = world real trade discrepancy
 $WTRADE$ = world nominal trade discrepancy
 t_i = weight of country i in world trade .

As the t_i are constructed to add to unity, these adjustments fully allocate the nominal and real discrepancies. The only change to the behavioural relationships is that import volumes now depend on PIMA in simulation as opposed to PIM. This means that the trade block is no longer fully recursive -- it is necessary to iterate on the trade equations in order for the discrepancies to converge to zero.

3. Estimation Results

For the purposes of estimation, we broaden the specifications shown in (2.1.1)-(2.1.4) to allow for more general dynamic processes. The approach taken was to add lags of the regressors and the dependent variable to the right-hand side of each equation, with constraints where necessary to ensure both theoretical consistency of the estimated parameters as well as adjustment

speeds which were plausible on prior grounds. In addition, shifts in the behavioural relationships over the estimation period unrelated to the basic model specification were accounted for by trend variables. In certain cases, common parameters have been imposed across the country blocks. This follows the general MULTIMOD/INTERMOD approach of imposing common parameters where separate estimates for each country are statistically indistinguishable, currently unavailable, or of implausible magnitudes.

3.1 Export Prices

The semi-reduced-form export price equation incorporates elements of both the supply and demand curves. The adjustment path of export prices to domestic and foreign price movements thus reflects shifts in both of these curves over time, and may be rather long given short-run factor immobility in export-producing sectors. Thus a dynamic specification was chosen which allows for a gradual adjustment process, while at the same time ensuring the homogeneity of export prices in domestic and foreign prices along the adjustment path. This was achieved by adding lags of domestic and foreign prices as well as a lagged dependent variable to the basic specification; the homogeneity conditions are satisfied by the imposition of parameter constraints.

MULTIMOD uses the following dynamic specification for export prices (where $d\ln(x)$ is the period-to-period change in the natural log of x):

$$\begin{aligned} \ln(PXM) = & \alpha + \beta d\ln(PGNPNO) + (1-\beta)d\ln(PFM) \\ & + \tau \ln(PGNPNO_{-1}) + (1-\tau)\ln(PXM_{-1}) . \end{aligned}$$

Because it is the change in the price in foreign markets which enters the equation, PXM depends only on domestic prices ($PGNPNO$) in full equilibrium -- i.e., the long-run supply curve of exports is constrained to be perfectly elastic. However, demand factors play a role in the short run to the extent that β is less than unity. The speed of adjustment to long-run values is determined by τ . In practice, τ is constrained to be the same for all countries in MULTIMOD: over the 1965-85 sample period, τ is estimated to be 0.067, while β ranges from 0.576 to 0.767.

INTERMOD embodies two principal changes to the MULTIMOD specification:

- Different rates of technical progress in the export- producing and domestic sectors of the economy are reflected in a trend term.
- The constraint that export prices be unit-elastic with respect to $PGNPNO$ in the long run is tested for explicitly rather than imposed.

We relax the constraint that the long-run supply curve of exports be perfectly elastic by adding the level of lagged PFM to the MULTIMOD equation.

At the same time, we maintain the constraint that PXM be homogeneous in a weighted average of PGNPNO and PFM in the short and long run.⁹ This gives:

$$\ln(\text{PXM}) = \alpha + \beta \ln(\text{PGNPNO}) + (1-\beta) \ln(\text{PFM}) + \delta \ln(\text{PFM}_{-1}) \\ + \tau \ln(\text{PGNPNO}_{-1}) + (1-\tau-\delta) \ln(\text{PXM}_{-1}) + \mu T .$$

Initial estimation results indicated that foreign prices do play a significant role in the long run determination of export prices, but that some of the individual parameter values were poorly defined. The approach taken was to pool the data and estimate the equations jointly, imposing the same long-run elasticity on PFM across countries.¹⁰ This implied imposing a non-linear constraint on the parameter associated with the lagged value of PFM -- the 'unscrambled' coefficients are shown in Table 3.1.

The coefficients on the time trends are negative, ranging in value from almost zero for Germany to -0.019 for Italy, indicating that the rate of technical progress has generally been faster in export-producing industries than in the aggregate economies of these countries. The weight on domestic prices in the short run ranges from a low of 0.46 in France to about 1 in the U.S. and the Small Industrials. The common long-run weight on domestic prices is 0.61, similar to the values found in the work of Herd (1987). The speeds of adjustment, as reflected in the sums of τ and δ , are typically higher than those found in the MULTIMOD estimation, ranging from 0.124 for Germany to about 1 for Italy.

Comparing the estimation results for Canada with those in the Department's Canadian forecasting model (CEFM), the weights in INTERMOD on domestic prices of 0.67 in the short run and 0.61 in the long run are both slightly higher than the average CEFM weight of 0.58 (which is the same in the short and long run). The U.S. model (USFM) has an average weight on domestic prices of 0.88, which is in the middle of the INTERMOD short-run weight of 1 and long-run weight of 0.61.

⁹ These constraints were tested for explicitly in estimation and not rejected at conventional levels of significance.

¹⁰ The long-run constraint was imposed by rewriting the equations as non-linear functions of τ and the common long-run value of δ . The optimal value for the long-run elasticity was then found through grid-search methods. The likelihood-ratio test of the null hypothesis that this parameter is zero yields a value of 15.2 (distributed $\chi^2(1)$), thus it is strongly rejected by the data. A test of the null hypothesis that the long-run parameters on foreign prices are the same across countries yielded a value of 14.0 (distributed $\chi^2(7)$), which is (slightly) below the critical value of 14.2 at a 95% level of significance.

Table 3.1
Export Price Equation Estimates

Equation:

$$\ln(PXM) = A_0 + A_1 \ln(PGNPNO) + (1-A_1) \ln(PFM) + A_2 \ln(PGNPNO_{-1}) \\ + A_3 \ln(PFM_{-1}) + (1-A_2-A_3) \ln(PXM_{-1}) + A_4 T,$$

where: PXM ■ price of manufactured exports
PFM ■ price in foreign markets
PGNPNO ■ GNP deflator excluding oil production
T ■ linear time trend (1960=1).

Estimated Parameters (1965-1985, absolute values of t-ratios in parentheses):

	<u>A0</u>	<u>A1</u>	<u>A2</u>	<u>A3</u>	<u>A4</u>	<u>R2</u>
US	0.051 (2.21)	1.008 (6.82)	0.470 (3.73)	0.288 *	-0.003 (2.42)	0.995
JA	0.667 (3.48)	0.525 (6.86)	0.423 (3.66)	0.259 *	-0.013 (3.39)	0.988
GR	-0.035 (1.15)	0.813 (9.37)	0.077 (0.87)	0.047 *	0.000 (0.19)	0.996
FR	-0.116 (2.56)	0.458 (5.43)	0.170 (1.91)	0.104 *	-0.002 (1.20)	0.998
UK	0.279 (2.91)	0.741 (10.39)	0.374 (3.16)	0.229 *	-0.003 (2.18)	0.999
IT	0.524 (4.36)	0.640 (3.33)	0.643 (4.71)	0.394 *	-0.019 (4.33)	0.998
CA	0.035 (1.16)	0.667 (5.25)	0.159 (1.69)	0.097 *	-0.004 (1.76)	0.992
SI	0.035 (0.62)	1.000 *	0.161 (1.89)	0.099 *	-0.003 (0.96)	0.986

* Constrained parameter: see text

3.2 Export Volumes

In MULTIMOD, equation (2.1.2) is adapted for estimation by adding a time trend to capture secular changes in shares of foreign import markets. At the same time, the coefficients on FM are constrained to unity, implying that import demands are homothetic with respect to country of origin. This ensures that a given change in world imports is reflected in a similar change in world exports without the necessity of allocating a large world trade discrepancy. In addition, MULTIMOD constrains the elasticities with respect to the real competitiveness index to be the same across countries. The estimation period is 1970-85, the starting point being determined by the availability of REER. The estimated long-run elasticity with respect to REER is -0.496, while the coefficients on the time trend range from -0.016 (U.S.) to 0.027 (Japan).

The principal difference between the INTERMOD and MULTIMOD export volume equations is that we include lagged values of the real competitiveness index, in the belief that the full effects on market shares of changes in relative prices are not felt immediately. In addition, we allow the price elasticities of export demand to vary across countries. The unit elasticity on FM is tested for (and accepted) in estimation.¹¹ Finally, an adjustment is made for first-order autocorrelation of the residuals. The estimated equation then is:

$$\ln(XM) = \alpha + \ln(FM) + \tau \cdot REER + \delta \cdot REER_{-1} + \mu \cdot T$$

Table 3.2 shows the results of the estimation of the export equations. The coefficients on the time trends suggest that growth in world imports has been biased towards the exports of Japan and the developing countries and away from the exports of most of the other industrial countries. In the case of the coefficients on REER, some of the contemporaneous effects were negative in unconstrained estimation. This problem was resolved by constraining the parameters for France, the U.K., and Italy to equal -0.2 in the first year, based on the extent to which these parameter values could be moved closer to those of the other countries without violating the statistical criterion of acceptance at conventional levels of significance. The highest short-run elasticity (in absolute value) with respect to REER is that for the rest of the world at -0.874. Most countries have a parameter on lagged REER which indicates a continuing effect from competitiveness changes (the lagged coefficient was constrained to zero if its freely-estimated value was positive). The long-run elasticities with respect to REER vary from -0.376 (Small Industrials) to -1.005 (Japan). The average long-run competitiveness elasticity of -0.461 is very close to the common MULTIMOD value of -0.496.

The full price elasticity of export demand depends on the response of the foreign markets variable to relative price movements. This can be derived from partial simulations of the import volume equations (as described below). The long-run results are as follows:

¹¹ A likelihood-ratio test yields a statistic of 15.7, distributed χ^2 with 9 degrees of freedom. The critical value at a 95% confidence level is 16.9.

Table 3.2
Export Volume Estimates

Equation:

$$\ln(XM) = A_0 + \ln(FM) + A_1 \cdot REER + A_2 \cdot REER_{-1} + A_3 \cdot T,$$

where: XM ■ manufactured exports volume
FM ■ foreign markets activity variable
REER ■ real competitiveness index
T ■ linear time trend (1960=1).

Estimated Parameters (1969-1985, absolute values of t-ratios in parentheses):

	<u>A0</u>	<u>A1</u>	<u>A2</u>	<u>A3</u>	<u>RHO</u>	<u>R2</u>
US	0.205 (4.56)	-0.220 (1.46)	-0.232 (1.52)	-0.019 (8.10)	0.257	0.990
JA	-2.031 (29.52)	-0.562 (3.01)	-0.443 (2.35)	0.025 (8.50)	0.390	0.996
GR	0.651 (30.53)	-0.231 (2.58)	-0.280 (3.60)	-0.010 (9.11)	0.312	0.998
FR	1.431 (27.46)	-0.200 *	-0.207 (1.12)	-0.008 (2.85)	0.536	0.995
UK	-0.499 (11.69)	-0.200 *	-0.177 (1.89)	-0.029 (15.99)	0.167	0.975
IT	-0.436 (5.07)	-0.200 *	-0.281 (1.60)	0.003 (0.76)	0.093	0.989
CA	-0.054 (0.45)	-0.423 (2.92)	-0.150 (1.01)	-0.002 (0.48)	0.576	0.994
SI	0.480 (26.27)	-0.376 (7.59)	0 *	-0.013 (13.32)	0.267	0.998
RW	0.331 (2.35)	-0.874 (4.75)	0 *	0.025 (3.65)	0.374	0.968

* Constrained parameter: see text

	Competitiveness Elasticity	Full Price Elasticity
U.S.	-0.45	-0.68
Japan	-1.01	-1.18
Germany	-0.51	-0.69
France	-0.41	-0.50
U.K.	-0.38	-0.51
Italy	-0.48	-0.55
Canada	-0.57	-0.73
Small Industrial	-0.38	-0.62
Rest of World	-0.87	-0.89

It can be seen that the full price elasticities are not dramatically higher than the competitiveness elasticities. The INTERMOD Canadian price elasticity of -0.73 is lower in absolute value than the CEFM value of -1.04.¹² The difference for the U.S. is more dramatic; the INTERMOD elasticity of -0.68 is considerably smaller than the USFM value of -1.3.

3.3 Import Volumes

The import volume equations in MULTIMOD are estimated by adding lagged values of absorption, relative import prices, import volumes, and a time trend to (2.1.3). The constraint is imposed that the long-run elasticity of imports with respect to absorption equal one. The coefficients on the time trends are positive and significant for the U.S. and Germany, while long-run price elasticities of demand range from -0.740 (Germany) to -1.646 (Large Industrials).

In most respects our approach is the same as that in MULTIMOD. The two principal differences are:

- We do not include a lagged dependent variable, in the belief that the long adjustment process often implied by a Koyck lag structure is inappropriate in the context of import demand functions. The dynamics are captured by the lagged values of relative prices and absorption, implying that adjustment is complete after two years. Corrections for first-order autocorrelation reflect serial dependence in the error term.
- We allow for a temporary 'overshooting' of imports, i.e. an elasticity with respect to absorption which differs from unity in the first year but falls back to one thereafter. This reflects the possibility that supply bottlenecks may exist in the domestic economy in the short run, causing the burden of adjustment to

¹² However, a recent re-examination of the export equations in CEFM indicates that the CEFM elasticity may be overstated. See Lamy [1988].

changes in demand to fall disproportionately on imports.

We maintain the long-run constraint that imports be unit-elastic with respect to absorption.¹³ Upward movements in import shares over the historical period are then explained by relative price movements and trend terms. The estimated equation is:

$$\ln(IM) = \alpha + \beta \ln(A) + (1-\beta) \ln(A_{-1}) \\ + \gamma \ln(PIM/PGNPNO) + \epsilon \ln(PIM_{-1}/PGNPNO_{-1}) + \mu * T$$

The estimation results are shown in Table 3.3. The parameters on the contemporaneous level of absorption suggest an overshooting effect in all of the countries except the U.K., Germany, and Japan, where the import response to a change in absorption is less than unity in the first year. (In all countries the response is constrained to equal one after two years.) In the case of Japan, the parameters on the contemporaneous and lagged values of absorption were poorly defined and the constraint was imposed that β equal one. Unconstrained estimates of the price elasticities yielded a wide range of values, varying from -0.180 in the case of the U.K. to -0.952 for the U.S. In the case of the U.K. and Canada, it was felt that the unconstrained elasticities were implausibly low relative to the estimates for the other countries. The U.K. elasticity was moved by about one standard error towards the other elasticities giving a value of -0.5, while the coefficient on lagged relative prices in the case of Canada was constrained to -0.2 to bring the long-run elasticity into line with those for the other countries. For Germany, an insignificant and wrong-signed coefficient on lagged relative prices was constrained to zero. The coefficients on the time trend are positive and significant for all countries (except Italy), suggesting that 'opening-up' effects have been important in explaining the rise in import shares over the historical period.

Even with the constraint on lagged prices to raise the responsiveness of imports to relative price movements, the long-run elasticity of import volumes with respect to price movements for Canada of -0.51 is substantially lower than the CEFM value of -0.84. In the case of the U.S., the elasticities are much closer, with INTERMOD showing a value of -0.95 compared to the USFM value of -1.0.

¹³ This constraint was rejected by the data: a likelihood ratio test yields a test statistic of 23.7 (distributed $\chi^2(8)$), compared to the critical value of 22.0 at a 99% level of significance. Nevertheless, the constraint was maintained in the belief that the unit elasticity is more appropriate in the context of the shock-minus-control experiments performed on INTERMOD. In future work we hope to explicitly capture the 'opening-up' effects that may underlie the secular increase in the import share of total absorption in the industrial countries.

Table 3.3
Import Volume Equation Estimates

Equation:

$$\ln(IM) = A_0 + A_1 \ln(A) + (1-A_1) \ln(A_{-1}) + A_2 T \\ + A_3 \ln(PIM/PGNPNO) + A_4 \ln(PIM_{-1}/PGNPNO_{-1}) ,$$

where: IM = volume of manufactured imports
A = total domestic absorption
PIM = price index of imports
T = linear time trend (1960=1).
RHO = first-order autocorrelation coefficient .

Estimated Parameters (1965-1985, absolute values of t-ratios in parentheses):

	<u>A0</u>	<u>A1</u>	<u>A2</u>	<u>A3</u>	<u>A4</u>	<u>RHO</u>	<u>R2</u>
US	-3.595 (146.59)	1.320 (8.29)	0.040 (38.69)	-0.233 (2.61)	-0.719 (7.27)	-0.348	0.996
JA	-3.184 (18.63)	1.000 *	0.031 (3.44)	-0.607 (2.36)	-0.209 (0.79)	0.278	0.984
GR	-2.140 (41.60)	0.862 (3.60)	0.031 (13.21)	-0.765 (4.65)	0 *	0.218	0.995
FR	-2.178 (21.77)	1.322 (7.65)	0.020 (4.52)	-0.057 (0.60)	-0.719 (7.07)	0.836	0.999
UK	-2.103 (15.93)	0.804 (2.12)	0.028 (4.23)	-0.500 *	0 *	0.704	0.979
IT	-1.912 (2.78)	1.631 (8.32)	0.013 (0.50)	-0.045 (0.20)	-0.471 (1.89)	0.925	0.997
CA	-2.141 (12.97)	1.643 (6.07)	0.030 (3.67)	-0.309 (1.02)	-0.200 *	0.368	0.994
SI	-1.822 (24.55)	1.804 (5.88)	0.028 (7.50)	-0.146 (1.26)	-0.590 (3.49)	0.280	0.996

* Constrained parameter: see text

4. Simulations of the Trade Block

The estimated trade block was simulated to evaluate the response of exports and imports to changes in the principal exogenous variables, i.e. domestic absorption, the non-oil output deflator, and the bilateral exchange rate vis-à-vis the U.S. dollar. It should be emphasized that these are partial shocks to the model's trade equations and thus do not incorporate feedback effects on domestic variables such as output and prices. The specific shocks that we consider are the following:¹⁴

1. The response of export volumes to a one per cent increase in each region's GDP deflator.
2. The response of import volumes to a one per cent increase in each region's GDP deflator.
3. The response of export volumes to a one per cent increase in each region's total absorption.
4. The response of nominal trade balances measured in U.S. dollars to a one per cent appreciation of each exchange rate vis-à-vis the U.S. dollar.

Given the dynamic adjustment processes in the volume and price equations, the simulation results depend on the time horizon chosen. Here we evaluate the results both in the first year of the shock as well as the long run. The elasticities will also depend to some extent on the levels of the variables in the control solution. This is because: (i) the equations are largely but not entirely log-linear, and (ii) the world trade discrepancy generated by the shocks differs because of the changed set of initial trade balances. In order to analyze the sensitivity of the results to the choice of base period, we have performed the shocks using both 1980 and 1985 values for the control solution. A final issue to be addressed is the treatment of the manufactured imports of the Rest of the World, as no explicit equation exists in the model -- rather, imports are determined by the external financing constraint faced by the developing countries. Here, parameters are assumed for an import volume equation similar to those for the industrialized countries. Specifically, the absorption elasticity is constrained to unity and the long-run relative price elasticity equals -0.6.

4.1 The Short-Run Trade Responses

The short-run responses of the trade sector to the shocks described above are shown in Table 4.1. The control solution is based on the 1985

¹⁴ Another response that might have been included is that of import volumes to a change in domestic absorption. However, because this elasticity has been constrained to unity in estimation, the responses will differ from the identity matrix only because of the allocation of the world trade discrepancy.

levels of the trade variables in the INTERMOD database.

Table 4.1.1 shows the percentage changes in export volumes given a 1 per cent rise in the domestic GDP deflator. The total responses reflect two channels of influence: (i) an increase in the GDP deflator raises both domestic and foreign export prices, tending to lower the competitiveness of the home country and raise that of trading partners, and (ii) import volumes of the home country increase in response to relative price movements (holding absorption constant), while those of trading partners fall. The diagonal elements give the own-country response of exports to increases in GDP deflator. These are all negative, reflecting both the decline in competitiveness and the reduced import volumes of trading partners. The off-diagonal elements are generally (but not necessarily) positive; the exports of some trading partners may decline when domestic prices rise, depending on their patterns of trade and the relative responsiveness of export prices to changes in foreign prices.¹⁵ In no case, however, do foreign exports fall by more than home-country exports in response to a rise in the domestic GDP deflator. The sum of the responses of a given country's exports to each of the price movements (i.e. the row sums in Table 4.1.1) are not necessarily equal to zero in the short run, as the response of export prices to GDP deflators varies across countries. In the long-run simulations presented below, exports volumes are homogeneous of degree zero in GDP deflators.

Table 4.1.2 shows the response of import volumes to a 1 per cent rise in the domestic GDP deflator. The diagonal elements are all positive and slightly smaller in absolute value than the estimated short-run elasticities with respect to the ratio of the GDP deflator to import prices. This is because import prices increase (slightly) in response to the rise in domestic prices. The off-diagonal elements are all negative, as foreign imports necessarily decline given the rise in import prices relative to their unchanged GDP deflators. The row sums in Table 4.1.2 are not necessarily zero in the short run for the reason discussed above.

The responses of exports to a 1 per cent increase in each country's total absorption are shown in Table 4.1.3. As import and export prices are unaffected in these partial simulations, the only channel of influence is the foreign markets variable. The diagonal elements would all equal zero in the absence of a world trade discrepancy, as home-country exports are not affected in the first instance by a change in domestic absorption. The allocation of the world trade discrepancy, however, generates small non-zero elements along the diagonal. The off-diagonal elements are all positive, their size reflecting the initial import level of the country whose absorption has increased, the amount by which import volumes 'overshoot' absorption changes in the short-run, and the importance of the trading relationship between the

¹⁵ As an example, French exports decline by 0.04 per cent in response to a 1 per cent rise in the U.S. GDP deflator. This is because France trades relatively little with the U.S. (whose import rise) compared to, e.g., the Rest of the World (whose imports fall). In addition, French export prices are relatively sensitive to foreign prices, reducing the competitiveness gains associated with higher U.S. prices.

Table 4.1
First-Year Trade Responses - 1985 Control Solution

Table 4.1.1: Export Volume Responses to Change in GDP Deflator

Export volume change in % for:	Increase of 1% in non-oil GDP deflator of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-0.33	0.09	-0.00	-0.02	0.00	-0.02	0.04	0.03	0.20
JA	0.08	-0.38	0.05	0.01	0.02	0.01	0.02	0.04	0.16
GE	-0.01	0.02	-0.25	-0.00	0.02	-0.01	-0.00	0.07	0.14
FR	-0.04	0.00	0.05	-0.13	-0.01	-0.03	-0.01	0.01	0.15
UK	-0.03	0.01	0.06	-0.02	-0.20	-0.02	-0.01	0.04	0.15
IT	-0.04	0.01	0.08	-0.02	-0.01	-0.18	-0.01	0.01	0.15
CA	0.09	0.07	0.01	-0.00	0.01	-0.00	-0.33	0.03	0.14
SI	-0.00	0.03	0.15	-0.02	0.04	-0.02	0.00	-0.27	0.09
RW	0.08	0.12	0.12	0.01	0.05	0.01	0.05	0.06	-0.48

Table 4.1.2: Import Volume Responses to Change in GDP Deflator

Import volume change in % for:	Increase of 1% in non-oil GDP deflator of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	0.23	-0.03	-0.02	-0.01	-0.01	-0.01	-0.04	-0.03	-0.05
JA	-0.25	0.59	-0.04	-0.02	-0.01	-0.01	-0.04	-0.10	-0.13
GE	-0.02	-0.05	0.72	-0.07	-0.09	-0.08	-0.00	-0.24	-0.17
FR	-0.00	-0.00	-0.02	0.06	-0.00	-0.01	0.00	-0.02	-0.01
UK	-0.06	-0.03	-0.08	-0.04	0.49	-0.03	-0.01	-0.14	-0.10
IT	-0.00	-0.00	-0.01	-0.01	-0.00	0.05	-0.00	-0.01	-0.01
CA	-0.20	-0.02	-0.01	-0.00	-0.01	-0.00	0.31	-0.03	-0.04
SI	-0.03	-0.01	-0.06	-0.02	-0.03	-0.01	-0.00	0.13	-0.03
RW	-0.07	-0.04	-0.04	-0.02	-0.02	-0.02	-0.01	-0.04	0.27

Table 4.1.3: Export Volume Responses to Change in Absorption

Export volume change in % for:	Increase of 1% in absorption of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-0.05	0.13	0.02	0.03	0.04	0.03	0.29	0.31	0.44
JA	0.38	-0.00	0.03	0.01	0.02	0.01	0.04	0.19	0.51
GE	0.06	0.01	-0.01	0.14	0.04	0.11	0.02	0.79	0.26
FR	0.03	0.01	0.11	-0.00	0.05	0.16	0.03	0.53	0.37
UK	0.10	0.01	0.10	0.07	-0.01	0.05	0.04	0.68	0.30
IT	0.05	0.01	0.13	0.17	0.04	-0.00	0.03	0.42	0.36
CA	0.82	0.07	0.00	0.01	0.02	0.01	0.02	0.12	0.19
SI	0.09	0.06	0.20	0.15	0.12	0.10	0.03	-0.02	0.32
RW	0.55	0.11	0.08	0.04	0.05	0.06	0.05	0.31	0.04

Table 4.1.4: Trade Balance Responses to Exchange Rate Movements

Trade balance change in US\$ for:	Increase of 1% in exchange rate of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	972	-69	-167	-86	-89	-86	-323	-278	129
JA	-921	-71	162	50	93	40	69	80	493
GE	-535	40	12	9	40	-15	1	147	296
FR	-184	-2	-73	386	-22	-78	4	-176	145
UK	5	-5	25	-37	25	-40	-10	-79	116
IT	-123	-10	-54	-77	-28	403	-4	-163	57
CA	-259	74	5	-2	14	-1	92	-34	111
SI	-768	41	-11	-106	-34	-92	2	803	168
RW	1813	2	102	-137	0	-132	170	-299	-1514

two countries. Thus the largest off-diagonal element represents the response of Canadian exports to a change in U.S. absorption, as all of these three factors are important.

The last matrix shows the responses of nominal trade balances in 'manufactured' goods measured in U.S. dollars to exchange rate changes in the short run, holding domestic price levels and absorption constant. The results depend to some extent on the choice of the U.S. dollar as the numeraire currency. In particular, an appreciation of the U.S. dollar tends to reduce both the dollar value of the initial trade surplus observed in the other industrial countries and the dollar value of the initial deficit in the Rest of the World.¹⁶ In most cases (with the exception of the Rest of the World and Japan) there is an improvement in the U.S. dollar trade balance given an exchange rate appreciation, reflecting the importance of 'J-curve' effects in the first-year responses of the model. As will be seen below in the long-run simulations, the perverse movements in trade balances are reversed over time such that all external balances deteriorate in the face of an exchange rate appreciation.

4.2 The Long-Run Trade Responses

The equations for export prices, export volumes, and import volumes all contain dynamic elements such that adjustment is spread out over more than one year. In the case of the latter two equations, adjustment is complete after two years. Because of the presence of the lagged dependent variable in the export price equation, this variable moves asymptotically to its long-run value with a mean adjustment lag which ranges from 1 year (U.S., Japan, U.K., and Italy) to a high of 4 years for Germany. In general, the responses of trade volumes to relative price movements are higher in the long run given the lagged adjustment to price changes, whereas the responses to absorption changes are smaller as the short-run overshooting of imports is reversed over time. We present results based on both 1980 and 1985 values for trade flows to illustrate their sensitivity to the choice of base period. In general, the results for the two base years are very similar.

The long-run responses based on 1985 values for the control solution are shown in Table 4.2. In terms of the responsiveness of export volumes to price changes, all of the diagonal elements in Table 4.2.1 are larger (in absolute value) than their short-run counterparts -- the average long-run response is -0.44 compared to the short-run value of -0.28. In addition, there are fewer negative off-diagonal elements, indicating that competitiveness effects are more important in the long run. The long-run responses of import volumes to price changes are also larger, with the diagonal elements in Table 4.2.2

¹⁶ The large surplus of the industrial countries and deficit of the Rest of the World reflects the exclusion of the commodity and oil exports of the latter region. As an example of the revaluation effect, the deterioration of US\$921 million in the Japanese trade balance in response to a U.S. dollar appreciation is consistent with an improvement of 37 billion Yen in the trade balance.

Table 4.2
Long-Run Trade Responses – 1985 Control Solution

Table 4.2.1: Export Volume Responses to Change in GDP Deflator

Export volume change in % for:	Increase of 1% in non-oil GDP deflator of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-0.46	0.13	-0.03	-0.02	-0.02	-0.02	0.06	0.04	0.29
JA	0.27	-0.71	0.05	0.03	0.02	0.02	0.01	0.08	0.27
GE	0.00	0.02	-0.45	0.02	-0.03	-0.00	-0.01	0.19	0.15
FR	-0.04	0.01	0.01	-0.32	-0.03	0.01	-0.01	0.10	0.22
UK	0.01	0.01	-0.01	-0.02	-0.34	-0.03	-0.02	0.14	0.18
IT	-0.01	0.02	0.04	0.03	-0.03	-0.34	-0.01	0.05	0.22
CA	0.50	0.05	-0.03	-0.02	-0.02	-0.01	-0.45	-0.03	0.10
SI	0.03	0.04	0.12	0.04	0.03	0.00	-0.01	-0.40	0.18
RW	0.33	0.11	0.04	0.01	0.00	0.00	-0.01	0.06	-0.52

Table 4.2.2: Import Volume Response to Change in GDP Deflator

Import volume change in % for:	Increase of 1% in non-oil GDP deflator of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	0.93	-0.13	-0.06	-0.03	-0.04	-0.02	-0.15	-0.14	-0.18
JA	-0.22	0.78	-0.05	-0.03	-0.02	-0.02	-0.05	-0.20	-0.17
GE	0.00	-0.05	0.73	-0.08	-0.07	-0.06	-0.00	-0.31	-0.15
FR	0.01	-0.03	-0.16	0.76	-0.05	-0.08	-0.00	-0.28	-0.13
UK	-0.03	-0.03	-0.06	-0.04	0.49	-0.03	-0.01	-0.18	-0.09
IT	-0.00	-0.02	-0.09	-0.05	-0.03	0.51	-0.00	-0.16	-0.09
CA	-0.23	-0.04	-0.03	-0.01	-0.02	-0.01	0.50	-0.09	-0.08
SI	-0.09	-0.07	-0.22	-0.10	-0.12	-0.06	-0.02	0.57	-0.15
RW	-0.12	-0.10	-0.07	-0.05	-0.05	-0.04	-0.02	-0.14	0.62

Table 4.2.3: Export Volume Responses to Change in Absorption

Export volume change in % for:	Increase of 1% in absorption of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-0.03	0.13	0.03	0.02	0.05	0.02	0.18	0.15	0.44
JA	0.30	-0.00	0.03	0.01	0.02	0.01	0.03	0.08	0.52
GE	0.06	0.01	-0.01	0.11	0.06	0.07	0.02	0.40	0.27
FR	0.03	0.01	0.12	-0.00	0.06	0.10	0.02	0.27	0.37
UK	0.09	0.01	0.12	0.06	-0.01	0.03	0.03	0.35	0.31
IT	0.05	0.01	0.15	0.13	0.05	-0.00	0.02	0.21	0.37
CA	0.64	0.07	0.00	0.01	0.03	0.01	0.01	0.04	0.20
SI	0.07	0.06	0.23	0.11	0.15	0.06	0.02	-0.03	0.33
RW	0.43	0.11	0.09	0.03	0.06	0.04	0.03	0.15	0.05

Table 4.2.4: Trade Balance Responses to Exchange Rate Movements

Trade balance change in US\$ for:	Increase of 1% in exchange rate of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	2086	454	29	5	22	1	231	306	1036
JA	-420	1102	173	98	103	64	67	202	813
GE	-390	63	895	135	5	43	-3	636	407
FR	-202	31	55	-416	-12	33	-7	179	338
UK	100	4	-3	-30	-272	-33	-19	72	183
IT	-81	19	29	22	-16	-163	-6	-8	204
CA	284	61	-21	-17	-9	-7	-283	-108	100
SI	-467	174	473	227	162	67	-15	-1327	704
RW	3262	298	160	-24	17	-6	36	49	-3785

Table 4.3
Long-Run Trade Sector Responses – 1980 Control Solution

Table 4.3.1: Export Volume Response to Change in GDP Deflator

Export volume change in % for:	Increase of 1% in non-oil GDP deflator of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-0.42	0.10	-0.01	-0.01	-0.01	-0.01	0.05	0.07	0.25
JA	0.19	-0.71	0.05	0.02	0.02	0.01	0.02	0.10	0.31
GE	-0.00	0.02	-0.43	0.04	-0.02	0.01	-0.01	0.24	0.16
FR	-0.03	0.00	0.03	-0.32	-0.03	0.01	-0.01	0.13	0.21
UK	0.00	0.00	0.02	-0.01	-0.32	-0.02	-0.01	0.18	0.17
IT	-0.02	0.01	0.05	0.05	-0.03	-0.34	-0.01	0.09	0.21
CA	0.41	0.04	-0.03	-0.02	-0.02	-0.01	-0.45	-0.01	0.09
SI	-0.01	0.03	0.13	0.05	0.02	0.00	-0.01	-0.38	0.17
RW	0.25	0.12	0.06	0.01	-0.00	0.00	-0.01	0.11	-0.52

Table 4.3.2: Import Volume Responses to Change in GDP Deflator

Import volume change in % for:	Increase of 1% in non-oil GDP deflator of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	0.87	-0.15	-0.07	-0.04	-0.06	-0.03	-0.17	-0.14	-0.22
JA	-0.25	0.79	-0.05	-0.03	-0.03	-0.02	-0.06	-0.17	-0.18
GE	-0.07	-0.04	0.73	-0.08	-0.08	-0.06	-0.01	-0.27	-0.13
FR	-0.07	-0.03	-0.16	0.75	-0.06	-0.08	-0.01	-0.24	-0.11
UK	-0.06	-0.03	-0.07	-0.04	0.49	-0.03	-0.01	-0.16	-0.08
IT	-0.05	-0.02	-0.10	-0.08	-0.04	0.51	-0.01	-0.14	-0.08
CA	-0.24	-0.04	-0.02	-0.02	-0.02	-0.01	0.50	-0.07	-0.08
SI	-0.10	-0.04	-0.17	-0.08	-0.10	-0.05	-0.02	0.66	-0.10
RW	-0.13	-0.09	-0.08	-0.06	-0.05	-0.04	-0.02	-0.13	0.62

Table 4.3.3: Export Volume Responses to Change in Absorption

Export volume change in % for:	Increase of 1% in absorption of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-0.02	0.12	0.04	0.03	0.05	0.02	0.16	0.19	0.42
JA	0.22	-0.00	0.04	0.01	0.02	0.01	0.02	0.13	0.56
GE	0.04	0.01	-0.01	0.11	0.05	0.07	0.01	0.46	0.26
FR	0.02	0.01	0.14	-0.00	0.06	0.11	0.01	0.31	0.36
UK	0.07	0.01	0.13	0.06	-0.01	0.03	0.02	0.40	0.29
IT	0.03	0.01	0.17	0.13	0.05	-0.00	0.01	0.25	0.35
CA	0.56	0.07	0.01	0.01	0.03	0.01	0.00	0.09	0.22
SI	0.05	0.05	0.25	0.12	0.14	0.06	0.01	0.01	0.32
RW	0.34	0.12	0.11	0.04	0.06	0.04	0.03	0.23	0.04

Table 4.3.4: Trade Balance Responses to Exchange Rate Movements

Trade balance change in US\$ for:	Increase of 1% in exchange rate of:								
	US	JA	GR	FR	UK	IT	CA	SI	RW
US	-2070	381	78	39	53	19	216	365	918
JA	-313	*889	126	63	63	40	53	212	644
GE	-360	68	-1043	166	13	58	-5	664	435
FR	-275	27	88	-479	-7	48	-10	239	367
UK	-192	6	44	-12	-203	-26	-19	187	214
IT	-108	14	35	22	-20	-177	-9	52	191
CA	158	46	-14	-14	-11	-7	-212	-13	68
SI	-371	198	621	288	166	87	-24	-1810	843
RW	3530	140	65	-73	-54	-42	10	104	-3681

averaging 0.65 compared to 0.32 in the short run. The off-diagonal elements also tend to be larger in absolute value. A comparison of Tables 4.2 and 4.3 reveals that the price responses change very little from 1980 to 1985. The differences are primarily due to the effect of changes in initial trade balances on the world trade discrepancy generated by the shocks.

The long-run responses with respect to changes in domestic absorption shown in Table 4.2.3 are generally smaller than the short-run values because of the reversal of the over-shooting of imports that is observed in most countries in the first year. For instance, Canadian exports rise by 0.64 per cent in the long run given a 1 per cent rise in U.S. absorption, compared to the short-run effect of 0.84 per cent. On the other hand, the 1985 responses are systematically greater than the 1980 responses shown in Table 4.3.3, reflecting the rise in the import share of total absorption in most countries over the intervening period. The row sums of Tables 4.2.3 and 4.3.3 equal 1, consistent with the constraint that exports be homogeneous in the long run with respect to changes in the size of foreign markets.

The long-run trade balance responses in U.S. dollars to an exchange rate appreciation are shown in Table 4.2.4. As mentioned above, J-curve effects are reversed in the long run and all countries experience a deterioration in the trade balance in response to an exchange rate appreciation. To give an idea of the relative effects on trade balances of exchange rate movements in these partial simulation exercises, we calculate the percentage increase in the exchange rate that would lead to a deterioration in the trade balance of 1 per cent of 1985 nominal GDP:

Country	Per Cent Change in Exchange Rate
U.S.	22
Japan	13
Germany	7
France	13
U.K.	17
Italy	25
Canada	13
Small Industrial	8
Rest of World	7

It is apparent that Italy has the least responsive external balance to exchange rate changes in these partial simulation exercises, while those of Germany, the Small Industrial countries, and the Rest of the World are the most responsive.

5. Conclusion

In this paper we have presented the specification and estimation results for the trade sector in INTERMOD. The estimated parameters are similar to those found for MULTIMOD, and yield responses of exports, imports, and trade balances consistent with those in other aggregate macro-economic models used

in the Department. The simulation results clearly show the importance of the short-run J-curve in muting the effect on trade balances of exchange rate movements, consistent with the experience since 1985 of a rather slow response of trade imbalances to exchange rate movements. However, the long-run effect on the trade balance indicates that the model is 'well-behaved' in terms of the stability of the market for foreign exchange.

Concerning possible directions for future research, the existing model has little to say about the sources of the secular rise in world trade volumes over the historical period, nor how long this upward trend is likely to continue. While this is not a serious problem given the current focus on using the model for policy simulation exercises as opposed to baseline forecasting, it would nevertheless be desirable to replace the time trends in many of the equations with more direct proxies for the factors that have expanded world trade. Another issue is the increasing globalization of production decisions in recent years and the implications for the modelling of trade flows. It may, for instance, be useful to include relative labour costs across countries in the export equations given possible distortions in the measurement of export prices due to international transfer pricing. Finally, further estimation will be performed to evaluate whether more country-specific institutional detail, such as the Canada-U.S. Autopact and the expansion of the EEC to include the U.K., adds significantly to the explanatory power of the estimated relationships.

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Appendix A

The Construction of PFM

Export prices in the model are a function of the domestic GDP deflator and an index of foreign price levels (PFM). In a simple model of supply and demand for exports, the parameters on these variables depend on the price elasticities of the supply and demand curves. This suggests that the weights used to aggregate the foreign prices in PFM should reflect the price responsiveness of domestic exports to changes in each of the foreign prices.

In MULTIMOD, the price in foreign markets facing country i is constructed using real competitiveness weights and export prices expressed in units of a common currency (i.e. U.S. dollars):

$$\ln(\text{PFM}_i) = \sum_j (w_{ij} * \ln(\text{PXM}_j * \text{ER}_j)) \quad (\text{A.1})$$

However, the use of competitiveness weights and export prices reflects only one component of the overall demand elasticity -- that related to changes in shares of foreign import markets. There is an additional effect insofar as price movements directly alter the level of each country's imports and thus foreign exports. In the case of the Canada-U.S. trading relationship, for instance, there is little competition in third markets, thus the weight on the U.S. in Canada's REER is only 0.093. However, a rise in U.S. domestic prices tends to lower U.S. imports, which has a large effect on Canadian exports -- with a price elasticity of demand close to unity, a 1 per cent rise in U.S. prices causes a 0.6 per cent fall in Canada's non-oil exports holding market shares constant.

Thus instead of using the competitiveness weights directly in PFM, we derive an alternative scheme based on a consideration of the full price elasticities of export demand. From equation (2.1.1), we have (assuming the homogeneity condition on FM that is imposed in estimation):

$$\begin{aligned} \ln(\text{XM}_i) &= \ln(\text{FM}_i) + \beta * \text{REER}_i \\ &= \ln(\sum_j \epsilon_{ij} * \text{IM}_j) + \beta * \sum_j w_{ij} * (\alpha * \ln(\text{PGNPNO}_j * \text{ER}_j)) \quad (\text{A.2}) \end{aligned}$$

where the second equality follows from the definitions of FM and REER and α is the long-run weight on domestic prices in the export price equation. Differentiating (A.2) to put it in terms of deviations from base-period values, and observing that FM_i equals XM_i in the base period gives:

$$\begin{aligned} d\ln(XM_i) &= (\sum_j s_{ij} * d\ln(IM_j)) / XM_i + \alpha * \beta * \sum_j w_{ij} * d\ln(PGNPNO_j * ER_j) \\ &= \sum_j l_{ij} * d\ln(IM_j) + \alpha * \beta * \sum_j w_{ij} * d\ln(PGNPNO_j * ER_j) , \end{aligned} \quad (A.3)$$

where the second equality follows from the fact that $l_{ij} = s_{ij} * (IM_j / XM_i)$. From the equation that determines home-country imports, we have the following response of import volumes to a change in domestic prices:

$$d\ln(IM_j) = \tau * \omega * d\ln(PGNPNO_j * ER_j) ,$$

where τ is the price elasticity of import demand and ω is less than unity, reflecting the response of import prices to a change in PGNPNO.

Substituting this into (A.3) gives:

$$d\ln(XM_i) = (\tau * \omega * \sum_j l_{ij} + \alpha * \beta * \sum_j w_{ij}) * d\ln(PGNPNO_j * ER_j) . \quad (A.4)$$

Expression (A.4) indicates that the elasticity of XM_i with respect to $PGNPNO_j$ is a function of both the l_{ij} and w_{ij} matrices, with weights which depend on the price elasticities of import demand, the responsiveness of export prices to domestic prices, and the competitiveness elasticities. Rather than undertaking constrained joint estimation of all the equations in the trade sector to obtain the values of τ , ω , α , and β for each country, we simply observed that typical values for these parameters obtained in unconstrained estimation of the price and volume equations indicated that the weights were of a similar order of magnitude. Thus the weighting scheme for PFM was based on a simple average of the l_{ij} and w_{ij} matrices. The final expression then is:

$$\ln(PFM_i) = \sum_j z_{ij} * \ln(PGNPNO_j * ER_j) ,$$

where: $z_{ij} = .5 * (l_{ij} + w_{ij})$.

Appendix B

The Derivation of the W Matrix

The second term in the equation for export volumes (2.3.3) measures the effect on country i's exports of changes in shares in foreign markets holding the level of foreign imports constant:

$$\text{share effect} = \sum_j ds_{ij} * (IM_j / XM_i) , \quad (B.1)$$

For instance, a rise in U.S. domestic prices increases U.S. import volumes, raising other countries' exports directly through the FM variable. In addition, the U.S. will lose export shares in foreign markets, tending to raise foreign exports through 'third-country' effects -- this second channel is captured by the REER variable in the model. Here we derive the W matrix used in the Samuelson-Kurihara approach to construct REER, based on the following model for the changes in the s_{ij} :

$$d\ln(s_{ij}) = (r-1) * d\ln(IM_j) + \beta * \sum_k (s_{kj} / (1-s_{ij})) * d\ln(PXM_k * ER_k / PXM_i * ER_i) . \quad (B.2)$$

The change in country i's share in country j's total imports is a function of the change in the level of j's imports, and the relative export price of competitors weighted by their share in j's imports. The parameter $(r-1)$ reflects the possible non-homotheticity of country j's import demands -- we assume that r equals one such that demands are homothetic and this term disappears. The parameter β measures the sensitivity of s_{ij} to changes in relative export prices.

Making use of the fact that $d\ln(X)$ is approximately equal to $d(X)/X$, the above equation can be rewritten as:

$$ds_{ij} = \beta * s_{ij} * \sum_k (s_{kj} / (1-s_{ij})) * d\ln(PXM_k * ER_k / PXM_i * ER_i) .$$

Substituting this into (B.1) gives:

$$\text{share effect} = \beta * \sum_j [s_{ij} * (IM_j / XM_i) * \sum_k (s_{kj} / (1-s_{ij})) * d\ln(PXM_k * ER_k / PXM_i * ER_i)]$$

which can be simplified to:

$$\text{share effect} = \beta * \sum_j [1_{ij} * \sum_k (s_{kj} / (1-s_{ij})) * d\ln(PXM_k * ER_k / PXM_i * ER_i)] .$$

To derive the competitiveness weights, it is useful to reverse the order of summation, giving:

$$\begin{aligned}
 \text{share effect} &= \beta * \sum_k [\sum_j (l_{ij} * s_{kj} / (1 - s_{ij}))] * d\ln(PXM_k * ER_k / PXM_1 * ER_1) & (B.3) \\
 &= \beta * \sum_k w_{ik} * d\ln(PXM_k * ER_k / PXM_1 * ER_1) \\
 &= \beta * REER_1 ,
 \end{aligned}$$

which demonstrates that the competitiveness weights generated by (B.3) are consistent with the model of import share determination described in (B.2).